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PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
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in its capacity as elected Office

Date of mailing (day/month/year) 05 September 2000 (05.09.00)	
International application No. PCT/SG98/00098	**Applicant's or agent's file reference** ST/62107
International filing date (day/month/year) 02 December 1998 (02.12.98)	**Priority date** (day/month/year)
Applicant LEONG, Foo, Yuen	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

10 June 2000 (10.06.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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1211 G n va 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Zakaria EL KHODARY

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
ST/62107		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SG98/00098	02/12/1998	02/12/1998
International Patent Classification (IPC) or national classification and IPC G10L19/14		
Applicant STMICROELECTRONICS ASIA PACIFIC PTE LTD ; et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10/06/2000	09.02.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer De Vos, L Telephone No. +49 89 2399 2048

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/SG98/00098

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-9 as published

Claims, No.:

1-4 as published

Drawings, sheets:

1/1 as published

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-4
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-4
Industrial applicability (IA)	Yes:	Claims	1-4
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

V. Reasoned Statement under Art. 35(2) PCT.

1. Although the claims appear to be novel over the prior art, they do not involve an inventive step over the prior art and therefore fail to fulfill the requirements under Art. 33(3) PCT.

2. Examination of claim 1

Document D1 ("VLSI DSP (MB8764) Based Adaptive Speech Codec", Matsumara et. al., ISCAS 1985, pp. 1121-1124), which is considered to represent the most relevant state of the art, discloses:

"A method for encoding speech or voice band data by way of adaptive differential pulse coded modulation (see Title of D1, and Abstract, l. 2) including an adaptive predictor procedure which implements an adaptive predictive filter for generating a signal estimate from quantized difference values (see D1, p. 1122, l. col. l. 27-29 and Fig. 1) and predictor coefficients (see "B1" in Sec. 5, p. 1123, l. col.) according to a predetermined multiplication and accumulation operation (see Sec. 5, p. 1123, l. col., l. 35-36),

wherein the quantized difference signal values are represented by single word length fixed point binary values (see p. 1124, l. col., l. 11-16),

including performing multiplication in fixed point format between the respective said predictor coefficients and the quantized difference signal values (same passage, combined with "DQ1" and "B1" in Sec. 5, p. 1123, l. col.)".

This wording is a large part of the wording of present independent method claim 1, which in consequence only differs from the state-of-the-art in that:

a) The predictor is also making use of "reconstructed signal values" (cl. 1, l. 6, l. 8, l. 10). This feature, however, does not cause claim 1 to involve an inventive step over the prior art, since it is inherently coupled to the use of the ITU-T Recommendation G.726. This Recommendation is the direct successor of Recommendation G. 721, in which this feature was not yet

provided, and for which the implementation in D1 was conceived.

After the Recommendation G.726 has appeared, it is obvious for the skilled person desiring to implement an ADPCM codec that he will focus on the G.726 instead of on the G.721 Recommendation, since the G.726 Recommendation provides considerably better codec quality. Therefore the skilled person will automatically also make use of "reconstructed signal values" in the predictor, as defined in G.726.

Consequently, the feature consisting in "making use of reconstructed signal values" does not cause present independent claim 1 to involve an inventive step over the prior art (Art. 33(3) PCT).

b) the multiplication of fixed-point format values results in double word length partial product values, which are summed to form a double word length predictor sum and rounded to a single word length fixed point representation.

This feature is at least not explicitly disclosed in D1, although it is, in the examiner's opinion, implicitly contained in Sec. 7 of D1.

However, even if this feature is considered as a novel feature, it would always not cause the claim to involve an inventive step over the prior art (Art. 33(3) PCT)for the following reasons:

The skilled person having to accumulate products of 16-bit integers would generally know that a typical multiplier-accumulator architecture for n-bit x n-bit words' multiplication needs a word length of 2xn bits for the partial products. Depending on the saturation characteristics of his arithmetics and on the maximum values possibly known to occur for the multiplier inputs, he will truncate or round either before or after the accumulation. This is merely dependent on the technical characteristics of the processor used for implementation, and the selection of one of these possibilities is a merely obvious and straightforward choice among the offered possibilities, according to the circumstances (see in this context e.g. D2, i.e., US-A-4876660, col. 1, l. 31-57, col. 2, l. 1-7).

Therefore, also the multiplication of fixed-point format values resulting in double word length partial product values, which are then summed to form a double word length predictor sum and rounded to a single word length fixed point representation, is not causing present claim 1 to involve an inventive step over the prior art (Art. 33(3) PCT).

c) For the sake of completeness, it is stated that no unexpected positive effect is emerging from the combination of the two features shown above to be obvious each.

As a matter of fact, there is no mutual interference at all between the two features, since they deal with two completely different aspects of the subject-matter (the choice of the algorithm for a), and the implementation on a fixed-point processor in b)).

Therefore it would be obvious for the skilled person to contemplate all the features set out in present independent method claim 1. Thus claim 1 does not involve an inventive step as required in Art. 33(3) PCT.

2. Present dependent claim 2 claims over and above claim 1 that

"said single word length representation comprises 16 bits and said double word length representation comprises 32 bits".

This feature does not cause present claim 2 to involve an inventive step over the prior art, since this feature merely represents one of several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to implement the algorithm on a fixed-point processor (see as an example D2, col. 2, l. 1-5).

For the sake of completeness only, it is stated here that there is no unexpected advantage emerging from the combination of the feature claimed additionally in claim 2 with any of the novel features in claim 1.

Consequently claim 2 is unacceptable under the PCT for lack of an inventive step

(Art. 33(3) PCT).

3. Present apparatus claims 3 and 4 are exactly corresponding to method claims 1 and 2, respectively.

   Therefore they fail to fulfill the requirements under the PCT for the same reasons already mentioned above for claims 1 and 2, respectively (lack of an inventive step, Art. 33(3) PCT.

VII. Certain defects.

4. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the document D1 is not mentioned in the description, nor is this document identified therein.

PATENT COOPERATION TRE

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
ST/62107		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/SG 98/00098	02/12/1998	

Applicant

STMICROELECTRONICS ASIA PACIFIC PTE LTD ; et al.

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

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[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. -

[ ] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[X] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SG 98/00098

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G10L3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06F G10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 876 660 A (OWEN ROBERT E ET AL) 24 October 1989 (1989-10-24) paragraph '0002! paragraph '0007!	1-4
Y	TOSHIHIKO MATSUMURA ET AL: "VLSI DSP (MB8764) BASED ADAPTIVE SPEECH CODEC" ION EXCHANGE, vol. PART 14, no. VOL. 50, 5 June 1985 (1985-06-05), pages 1121-1124, XP000012513 ANTWERPEN F J VAN column 1, line 31 - line 50	1-4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 July 1999	03/08/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Krembel, L

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

...ation on patent family members

International Application No
PCT/SG 98/00098

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4876660 A	24-10-1989	US 4841468 A	20-06-1989

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G10L 3/02 | A1

(11) International Publication Number: WO 00/33293

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(21) International Application Number: PCT/SG98/00098

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(71) Applicant *(for all designated States except US)*: STMICROELECTRONICS ASIA PACIFIC PTE LTD [SG/SG]; 28 Ang Mo Kio Industrial Park 2, Singapore 569508 (SG).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: LEONG, Foo, Yuen [SG/SG]; Block 102 Commonwealth Crescent, #10–108, Singapore 140102 (SG).

(74) Agent: DONALDSON & BURKINSHAW; P.O. Box 3667, Singapore 905667 (SG).

(81) Designated States: JP, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FIXED–POINT MULTIPLICATION FOR ADPCM SPEECH CODER

(57) Abstract

The ITU–T Recommendation G.726 specifies an ADPCM algorithm for the encoding of speech signals. In the adaptive predictor block of the algorithm, a floating point multiplication routine is specified for the calculation of the signal estimate. This routine is computationally intensive and accounts for 30 % of the MIPs requirement for the algorithm. A fixed–point multiplication is proposed as a replacement, which makes use of the availability of 40–bit accumulators. The new routine provides a significant reduction in the MIPs requirement and also improves speech quality.

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FIXED-POINT MULTIPLICATION FOR ADPCM SPEECH CODER

Field of the Invention

This invention relates to the implementation of a digital speech coder for the transmission of speech or voice band data over a communications network.

Background of the Invention

In order to transmit speech or voice band data over a communications network in a digital form, one of the methods that may be used to encode the input data for transmission is Adaptive Differential Pulse Coded Modulation (ADPCM). The ADPCM algorithm achieves speech compression by combining adaptive quantization and differential PCM. Adaptive quantization adjusts the step size of the quantizer as the signal changes. This allows the algorithm to accommodate variations in the signal amplitude. Differential PCM involves transmitting the difference between the current and previous signal sample instead of simply transmitting the current sample itself. The difference signal obtained in this way tends to have a much lower dynamic range compared to the original signal and may therefore be quantized to a specific signal-to-noise ratio with fewer bits.

In practice, the difference signal is computed from the current signal sample and a signal estimate determined by an adaptive predictor. The adaptive predictor uses signal estimates of previous samples to obtain an approximation of the current sample. This is performed in both the encoder and decoder so that they are synchronised with each other and there will not be any accumulation of errors in the reconstructed signal at the decoder output.

In ITU-T Recommendation G.726, the adaptive predictor is represented by a two-pole, six-zero adaptive predictive filter. The combination of poles and zeros enables the filter to deal with any general input signal. The sixth-order all-zero filter is needed to stabilise the filter and prevent it from drifting into oscillation. The filter coefficients are updated based on a

simplified gradient algorithm.

The signal estimate is computed by:

$$s_e(k) = \sum_{i=1}^{2} a_i(k-1)s_r(k-i) + \sum_{i=1}^{6} b_i(k-1)d_q(k-i)$$

where s_e : signal estimate

s_r : reconstructed signal

d_q : quantized difference signal

a_i, b_i : predictor coefficients

The range of values of the predictor coefficients is limited to ± 2 and are stored as 16-bit fixed point values. The quantized difference signal and reconstructed signal can vary between -32768 to 32767. Initially 16-bit fixed point values, they are then converted to floating point and stored. The aforementioned ITU-T recommendation specifies that the multiplication operation should be performed in floating point, by converting all inputs to floating point values with 6 bits of mantissa and 4 bits of exponent. The resulting product is then converted back into a 16-bit fixed point number.

Summary of the Invention

In accordance with the present invention, there is provided a method for encoding speech or voice band data by way of adaptive differential pulse coded modulation including an adaptive predictor procedure which implements an adaptive predictive filter for generating a signal estimate from quantized difference signal values, reconstructed signal values and respective predictor coefficients according to a predetermined multiplication and accumulation operation, wherein the quantized difference signal values and reconstructed signal values are represented by single word length fixed point binary values, including performing multiplication in fixed point format between the respective said predictor coefficients and the quantized difference

signal values and reconstructed signal values to generate respective double word length fixed point partial product values, summing the double word length fixed point partial product values to form a double word length predictor sum and rounding the predictor sum to a single word length fixed point representation of said signal estimate.

The present invention also provides An adaptive differential pulse coded modulation encoder for encoding speech or voice band data for transmission over a communications network, including an adaptive predictor having an adaptive predictive filter for generating a signal estimate from input quantized difference signal values, input reconstructed signal values and respective predetermined predictor coefficients, wherein the quantized difference signal values and reconstructed signal values are represented by single word length fixed point binary values, the adaptive predictive filter including a multiplier which performs multiplication in fixed point format between the respective said predictor coefficients and the quantized difference signal values and reconstructed signal values to generate respective double word length fixed point partial product values, and an accumulator for summing the double word length fixed point partial product values to form a double word length predictor sum and rounding the predictor sum to a single word length fixed point representation of said signal estimate.

Preferably the single word length representations comprise 16 bit binary values and the double word length representations comprise 32 bit binary values. However, it will be appreciated that other length words are possible within the scope of the invention, depending upon the type of computational processing equipment the invention is to be implemented on.

The invention is described in greater detail hereinafter, by way of example only, through description of a preferred embodiment thereof and with reference to the accompanying drawing which illustrates a generalised block diagram of an ADPCM encoder.

Detailed Description of the Preferred Embodiment

The present invention relates to adaptive differential pulse coded modulation (ADPCM) of speech or voice band data for transmission over a communications network, of the type which is described in ITU-T Recommendation G.726, the disclosure of which is incorporated herein by reference. The ADPCM encoder in the ITU-T recommendation converts a 64 kbit/s PCM input into an ADPCM compressed output for transmission. The accompanying drawing figure illustrates a block diagram of an ADPCM encoder according to the ITU-T recommendation. Referring to the figure, an A-law or μ-law PCM input stream is first converted to uniform PCM. A difference signal is then obtained by subtracting an estimate of the input signal from the input signal itself. An adaptive quantizer is used to assign a quantized value of a predetermined number of binary digits to the value of the difference signal for transmission to the decoder. An inverse adaptive quantizer is arranged to produce a quantized difference signal from the quantized value output from the adaptive quantizer. The input signal estimate is added to the quantized difference signal to produce the reconstructed version of the input signal. Both the reconstructed signal and the quantized difference signal are operated upon by an adaptive predictor which produces the input signal estimate, thus forming a feedback loop.

The embodiment of the invention herein described is concerned primarily with the adaptive predictor portion of the ADPCM encoder, and in particular the filtering operation of the adaptive predictor. Because of the floating point multiplications, the filtering operation of the adaptive predictor is the most complex block of the ADPCM algorithm. According to the ITU-T recommendation, this involves first converting the fixed point inputs to floating point, multiplying the mantissas and adding the exponents, and finally converting the floating point product back to fixed point representation. In addition to the computational complexity of this operation, when the values d_q and s_r are close to the 16-bit limit, converting them to floating point will result in a loss of precision even before the multiply operation can take place. This is because only 6 bits are retained for the mantissa of the floating point number.

The preferred embodiment of the present invention provides a way in which to perform the operations more efficiently and accurately.

Since all the input values are originally available in 16-bit fixed point format, it is possible to perform the multiplication directly in fixed point. This eliminates the need to convert the values between fixed and floating point formats. To reduce the errors due to loss of precision, the full 32-bit intermediate products are kept during accumulation. At the end of the filter operation, the final accumulated product is then rounded off to 16 bits.

The preferred embodiment of the invention primarily involves four function blocks that are defined in ITU-T Recommendation G.726, namely the FLOATA, FLOATB, FMULT and ACCUM blocks. The functions of these blocks as utilised in the ITU-T recommendation are described briefly below with reference to the figure and the signal estimate equation mentioned above.

FLOATA: This block receives the quantized difference signal d_q as input, where the quantity d_q is defined as a 15 or 16 bit signed binary magnitude. The quantized difference signal d_q is converted into a floating point value. This is performed by computing the exponent and mantissa and combining the sign bit, 4 exponent bits and 6 mantissa bits into one 11 bit word.

FLOATB: This block receives the reconstructed signal s_r as input, where the quantity s_r is defined as a 16 bit twos-complement quantity. The reconstructed signal s_r is converted into a floating point value. This is performed by computing the exponent and mantissa and combining the sign bit, 4 exponent bits and 6 mantissa bits into one 11 bit word.

FMULT: This block multiplies predictor coefficients with the corresponding quantized difference signal or reconstructed signal. The multiplication is done in a floating point format, and thus the predictor coefficients, which are defined as

16 bit twos-complement quantities, are first converted into floating point representations. The products of the multiplication operations are signal estimate partial products (WAn, WBn), which are also defined as 16 bit twos-complement quantities, requiring a conversion from the floating point multiplication result.

ACCUM: This block operates on the signal estimate partial products to perform the summing portion of the operation represented by the equation discussed above. The partial products of the signal estimates (WA1, WA2, WB1, WB2, WB3, WB4, WB5 and WB6) are received as input and summed to obtain the complete signal estimate s_e. All of the quantities are twos-complement representations.

The preferred embodiment employs fixed point multiplication rather than floating point computation, which requires a number of modifications as described below. Replacing the floating point multiplication with a fixed point multiplication eliminates the need to convert values between fixed and floating point formats. This significantly reduces the complexity of the overall algorithm. By omitting the fixed-to-floating point conversion, the full precision of the original values is preserved, thereby reducing errors due to loss of precision. As a result, an improvement in the quality of the decoded signal can be achieved. The primary modifications to the ITU-T recommended ADPCM adaptive predictive filter which are implemented in the preferred embodiment are summarised below.

The FLOATA block ordinarily takes the reconstructed signal and converts it from 16-bit signed magnitude format to floating point. This block is re-defined to convert the signed magnitude numbers to 16-bit twos-complement numbers instead. The FLOATB block ordinarily takes the signal estimate and converts it from 16-bit twos-complement to floating point. This block is no longer needed and is discarded from the system.

The FMULT block normally performs several functions, namely converting the predictor

filter coefficients from 16-bit twos-complement to floating point, performing floating point multiplication by adding the exponents and multiplying the mantissas and finally converting the product back into a 16-bit twos-complement number. The preferred embodiment requires that all these functions be discarded and replaced by a simple fixed-point multiplication which multiplies two 16-bit twos-complement numbers to give a 32-bit product. The full 32 bits of the result is retained. No truncation to 16 bits is performed.

The ACCUM block ordinarily adds the 16-bit predictor outputs together to form the signal estimate. The preferred embodiment requires that the accumulation function be modified to operate on 32-bit inputs. After the final accumulation, the result is then rounded off to 16 bits to give the signal estimate.

Thus, the preferred embodiment of the invention requires the ability to perform 16x16 bit fixed-point multiplication and to store the 32-bit result for subsequent arithmetic operations. The following procedures, in pseudocode, implement the preferred embodiment by redefining the FLOATA, FLOATB, FMULT and ACCUM blocks originally specified in ITU-T G.726. The modified procedures in combination retain the functionality of the ITU-T recommendation, although not in strict compliance with the specification. Table 1, below, provides a description of the format of the variables used in the procedures.

Name	Bits	Binary representation	Description
A1, A2	16 TC	S, 0, ...,-14	Delayed second order predictor coefficients
B1, ..., B6	16 TC	S, 0, ...,-14	Delayed sixth order predictor coefficients
DQ	16 SM	S, 14, ..., 0	Quantized difference signal
DQ0	16 TC	S, 14, ..., 0	Quantized difference signal with delay 0
DQS	1 TC	S	Sign bit of quantized difference signal
SE	15 TC	S, 13, ..., 0	Signal estimate
SEZ	15 TC	S, 13, ..., 0	Sixth order predictor partial signal estimate
SR	16 TC	S, 14, ..., 0	Reconstructed signal
SR0	16 TC	S, 14, ..., 0	Reconstructed signal with delay 0
SR1, SR2	16 TC	S, 14, ..., 0	Reconstructed signal with delays 1 and 2
WA1, WA2	32 TC	S, 16, ..., -14	Partial product of signal estimate
WB1,..,WB6	32 TC	S, 16, ..., -14	Partial product of signal estimate

TC denotes twos-complement representation

SM denotes signed magnitude representation

S denotes sign bit

Table 1 Format and description of variables

Procedure 1: FLOATA

Function: Convert 16-bit signed magnitude to 16-bit two's complement

```
DQS = DQ >>15                  | Get the sign bit.
DQM = DQ & 32767               | Compute magnitude.
if DQS = 1, DQ0 = DQM          | Convert magnitude to
else DQ0 = -DQM                | twos-complement.
```

Procedure 2: FLOATB

Function: Copy 16-bit twos-complement number from input to output

```
SR0 = SR
```

Procedure 3: FMULT

Function: Multiply predictor coefficients with corresponding quantized difference signal or reconstructed signal. Multiplication is done in fixed point format.

```
WAn = An x SRn          | Perform fixed point
WBn = Bn x DQn          | multiplication.
```

Procedure 4: ACCUM:

Function: Addition of predictor outputs to form the partial signal estimate (from the sixth order predictor) and the signal estimate.

```
SEZI = WB1 + WB2 + WB3 + WB4 + WB5 + WB6  |Sum for partial signal estimate.

SEI = SEZI + WA2 + WA1                    | Complete sum for signal
                                          | estimate.
SEZ = SEZ1 >> 14
SE = SEI >> 14
```

The foregoing detailed description of the preferred embodiment of the invention has been presented by way of example only, and is not intended to be considered limiting to the invention as defined in the claims appended hereto.

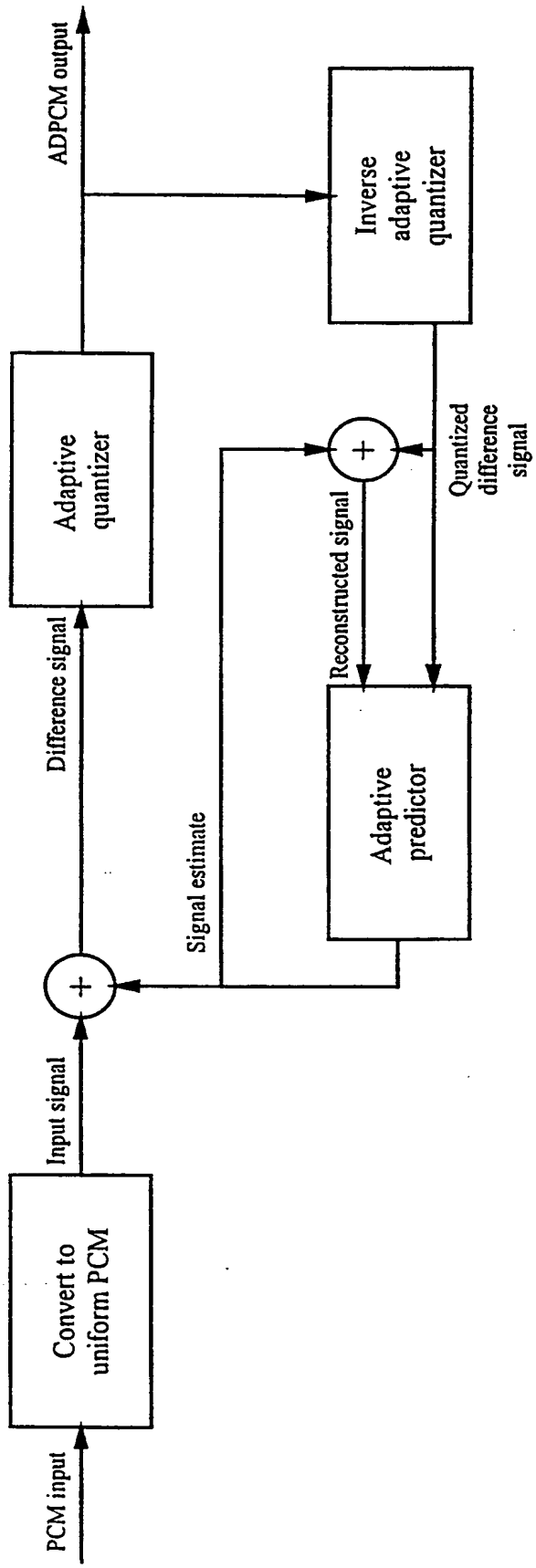
Claims:

1. A method for encoding speech or voice band data by way of adaptive differential pulse coded modulation including an adaptive predictor procedure which implements an adaptive predictive filter for generating a signal estimate from quantized difference signal values, reconstructed signal values and respective predictor coefficients according to a predetermined multiplication and accumulation operation, wherein the quantized difference signal values and reconstructed signal values are represented by single word length fixed point binary values, including performing multiplication in fixed point format between the respective said predictor coefficients and the quantized difference signal values and reconstructed signal values to generate respective double word length fixed point partial product values, summing the double word length fixed point partial product values to form a double word length predictor sum and rounding the predictor sum to a single word length fixed point representation of said signal estimate.

2. A method as claimed in claim 1, wherein a said single word length representation comprises 16 bits and a said double word length representation comprises 32 bits.

3. An adaptive differential pulse coded modulation encoder for encoding speech or voice band data for transmission over a communications network, including an adaptive predictor having an adaptive predictive filter for generating a signal estimate from input quantized difference signal values, input reconstructed signal values and respective predetermined predictor coefficients, wherein the quantized difference signal values and reconstructed signal values are represented by single word length fixed point binary values, the adaptive predictive filter including a multiplier which performs multiplication in fixed point format between the respective said predictor coefficients and the quantized difference signal values and reconstructed signal values to generate respective double word length fixed point partial product values, and an accumulator for summing the double word length fixed point partial product values to form a double word length predictor sum and rounding the predictor sum to a single word length fixed point representation of said signal estimate.

4. An adaptive differential pulse coded modulation encoder as claimed in claim 3, wherein a said single word length representation comprises 16 bits and a said double word length representation comprises 32 bits.



ADPCM Encoder